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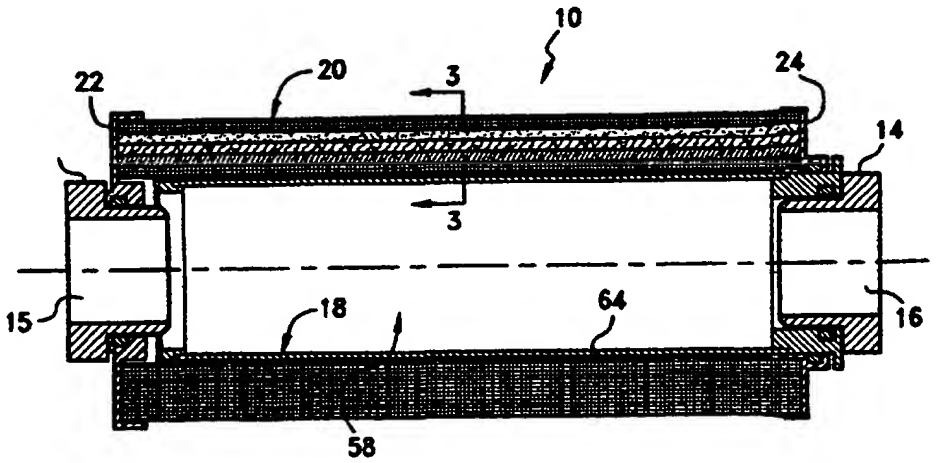
(54) Title: CORELESS NON-METALLIC FILTER ELEMENT




(57) Abstract

A coreless filter element (10) for a filter housing includes cylindrical filter media (20) having longitudinally-extending pleats extending from one end cap (22) on the filter media to another end cap (24) on the filter media. The filter media (20) is preferably a multi-layered structure with an outer support mesh layer attached to an inner prefiltration layer by an intermediate adhesive web layer. An inner wrap (64) of a porous fibrous filter media is provided within the central cylindrical cavity (58) of the pleated filter media (20). The wrap (64) has a cylindrical form with an outer surface which is joined to the inner pleat peaks of the media such as with adhesive applied in one or more beads, or as a continuous layer applied to the outer surface of the support wrap. The filter element (10) with inner support wrap (64) can be easily located over the metal support core (18) integral with the filter housing, and provides structural integrity for the pleats of the filter media. According to another embodiment, a series of circumferential bands formed from porous or imperforate material can be provided within the central cylindrical cavity (58) and joined by the adhesive to the inner pleat peaks of the filter media.

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Title of Invention **CORELESS NON-METALLIC FILTER ELEMENT**

The present invention relates generally to filter elements, and more particularly, to a coreless filter element, that is, a filter element which can be located over a rigid support core integral with the filter housing, and can be removed from the support core and replaced when the filter element becomes used or spent.

Some filter elements include a perforated rigid support core surrounded by tubular or cylindrical fibrous filter media. Imperforate rigid plastic or metal end caps are typically located at opposite ends of the filter media, and at least one of the end caps has a central opening to allow fluid to flow into or out of the inner cavity of the filter element. The filter element can be located in a filter housing, with the element locators (fluid passages) in the housing received in the opening(s) in the end caps. In some instances, the filter media is pleated, that is, the filter media is formed with longitudinally-extending pleats extending from end cap to end cap. The pleats provide for a larger surface area in contact with fluid to be filtered, and hence increase the particle separation efficiency of the filter element. Fluid to be filtered either passes radially inward through the filter media and then outwardly through the opening in the end cap, or inwardly through the opening in the end cap and then radially outward through the filter media.

The support core for the filter element generally provides support for the pleated filter media, although certain filter media structures have been developed whereby the filter material is of such a rigidity that it is self-supporting. Self-supporting filter elements can require relatively thick media layers, epoxy-coated steel mesh layers, deep grooves in the exterior surface to increase the surface area, shallow pleat configurations, and/or a high resin content, all of which can increase the complexity, time, and cost associated with manufacturing the filter element. Self-

supporting filter elements are therefor not appropriate for all filter applications. As such, many applications require a central support core for support of the filter media.

Applicants believe that filter elements with a central support core have typically been manufactured with the core formed integrally with the housing, that is, with the core fixedly attached to the surrounding filter media, such as by attachment to the opposing end caps (see, e.g.,Patent Specification US-A-4,033,881). As such, when the filter element becomes clogged or spent, the entire element, with support core, must be removed and replaced. Many fibrous filter elements are not designed to be cleaned and reused, and as such, must be disposed of in an appropriate location, such as in a landfill. The support core is not easily removed from the filter media, and as such, the core is disposed of at the same time. These two components (filter media and core) take up valuable space in landfills. Additional disposal issues can be raised when the support core is formed from a non-combustible material, such as metal, which can require the use of expensive compacting machinery for proper disposal. Moreover, the replacement filter element has costs (labor and material) associated with both the fresh filter media and the support core, particularly if the core is metal.

Certain filter elements have been developed in an attempt to separate (remove) the spent filter media from the support core when the filter media is replaced. These "green" filter elements include, for example, Patent Specification US-A-5,476,585 to Mills, which shows a permanent metal support core in the housing surrounded by a removable pleated filter element. A spiral wrap is disposed around the exterior surface of the filter media to provide resistance against axially-directed forces. End cap portions on the filter media and on the core are fluidly sealed together and can be separated to remove the spent filter media from the core. Patent Specification US-A-4,211,543 to Tokar, et al., also shows a pleated filter media having an outer liner supporting the outer pleat peaks of the media. This reference also discloses that the filter media can be slid onto a conically-shaped safety sleeve assembly, which has been initially located over a rigid support core. Patent Specification US-A-5,211,846 to Kott et al., discloses to provide circumferential

straps around the exterior of the coreless filter element to maintain the cylindrical shape of the filter media and to maintain separation of the pleats. On the other hand, Patent Specification US-A-5,413,712 to Gewiss et al., discloses to locate pleated (zig-zag) filter media directly over a rigid support core with no external wrap.

While the Mills, Tokar, Kott and Gewiss patents appear to allow the filter media to be removed from a support core permanently affixed to the filter housing, it is believed that the filter media can be difficult to locate over the core, particularly if the filter media is pleated because the inner peaks of the pleats can become distended or bent when the filter element is closely received over the support core. Further, the pleated filter media requires some structure to hold the pleats in fixed, closely-held relation with one another such that "lay-over", i.e., the folding over of the pleats against one another, is prevented. While the Mills, Tokar and Kott patents teach to provide an exterior wrap around the pleats, wrapping the exterior surface, particularly with a helical or spiral wrap, can be time-consuming and require significant amounts of wrap material. An exterior wrap can also have issues with appearance. The Gewiss patent, on the other hand, does not provide an outer wrap, and so can be unacceptable for many applications where a significant pressure drop across the element is expected.

As such, it is believed that the prior known designs for filter elements have not provided a coreless filter element which can be simply and easily located over a support core in the housing and removed from the housing when spent and replaced, which has a filter media structure which maintains the structural integrity of the pleats during use, and which is relatively simple and cost-effective to manufacture. Moreover, it is believed that there is a demand in the industry for a coreless filter element which does not have an outer wrap around the pleats, does not incorporate the drawbacks associated with many of the "self-supporting" types of filter elements, and which can be easily disposed of in landfills.

According to one aspect of the invention there is provided a coreless filter element, comprising cylindrical filter media having longitudinally-extending pleats extending from one end of

the filter media to another end of the filter media. The pleats have closed ends, open ends, and opposing sidewalls extending between respective closed ends and open ends which define outwardly-opening pleat cavities around the filter element. A radially-inner surface of the closed ends of the pleats defines a central, longitudinally-extending cylindrical cavity within the filter media, and an inner cylindrical support wrap formed from a layer of porous, fibrous filter media is disposed within the central cavity and has a radially outer surface joined to the radially-inner surface of the closed ends of the pleats.

A new and unique corless filter element in such an arrangement can be located over a rigid support core integral with the filter housing, and can be easily removed from the support core and replaced when the filter element becomes spent or used. The filter element has filter media with a structure which maintains its structural integrity during use without the need for an outer wrap, and which is relatively simple and cost-effective to manufacture. The filter element does not incorporate metal components, which thereby allows the element to be disposed of in commercial landfills such as by biodegration or incineration.

According to the principles of the present invention, the filter element comprises cylindrical filter media having longitudinally-extending pleats extending from one end of the filter media to the other end. Imperforate plastic end caps are disposed at each end of the filter media. According to one embodiment, an inner cylindrical support wrap of a porous, fibrous filter media is disposed centrally within the filter media and has an outer surface which is joined to the inner peaks of the pleats. The support wrap is preferably a non-woven polyester or other spun-bonded material, and can be joined to the inner peaks such as by adhesive applied in one or more beads on the outer surface of the wrap, or in a layer across the entire surface of the wrap. The support wrap preferably extends along substantially the entire length of the filter media between the end caps and fixidly locates the pleats with respect to one another for structural integrity. The support wrap also allows the filter element to be easily slid onto or off of a rigid support core without damaging the pleated media.

The filter element of the present invention is also relatively easy to manufacture with an inner support wrap. The support wrap is preferably initially disposed over a mandrel, with the side edges of the support tube being overlapped. Adhesive is then applied around the outer surface of the support wrap in one or more beads, or in a layer across the entire surface. The corrugated filter media is then located over the support tube in a cylindrical form, with the inner pleat peaks being adhesively joined to the support tube. The side edges of the filter media are then attached together using, e.g., a band or ribbon of adhesive. The end caps are then located on opposite ends of the filter element to provide additional structural integrity for the filter element, and allow the filter element to be located within the element locators in the filter housing.

According to another embodiment of the present invention, one or more support bands are disposed around the inner circumference of the pleated filter media. Preferably three bands are provided, with one band located close to each end of the filter media, and with the remaining band at about the midpoint of the filter media. The bands are preferably formed from an imperforate material, such as nylon, but can also be formed from fibrous filter material similar to the support wrap. The bands are joined to the inner pleat peaks by adhesive applied to the outer surface of the bands, and can extend in an annulus around the inner peaks of the pleats, or in a spiral or helical fashion.

In either of the embodiments described above, the inner support wrap or bands provide structural integrity for the pleats and allow the filter element to be easily manufactured using common techniques. The wrap or bands also allow the filter element to be easily located over a support core integral with a filter housing, and removed from the core and replaced when the filter element becomes used or spent.

The filter media of the present invention is preferably a multilayered filter media structure. Specifically, the filter media preferably has an outer support mesh layer, an adhesive web layer, a microfiber capacity layer (prefiltration layer), a microfiber filtration layer, and finally, an inner support mesh layer, all disposed in adjacent, surface-to-surface contact with one another. The

adhesive web layer is preferably a non-woven, polyester-based thermoplastic which joins the outer support mesh layer to the prefiltration layer and also provides structural integrity for the pleated structure of the filter media when the filter media is under pressure. This preferred filter media structure can be disposed of in a landfill such as by biodegration or by incineration. While one preferred form of the filter media structure is thus described, it should be apparent that the filter element can be used with other types of pleated filter media structures, as should be apparent to those skilled in the art.

As such, the present invention provides a filter element which can be simply and easily located over a support core integral with the filter housing, and easily removed and replaced when the filter element is spent. The filter element has a filter media structure which maintains the structural integrity of the pleats during use, and which is relatively simple and cost-effective to manufacture. Further, the filter element is formed from biodegradable or combustible components which allow the filter element to be relatively easily disposed of in commercial landfills without significant expense, such as without the use of expensive compacting machinery.

The invention is diagramatically illustrated by way of example in the accompanying drawings in which:

Figure 1 is a left end view of a filter element constructed according to the principles of the present invention, the right end view being smaller;

Figure 2 is a cross-sectional side view of the filter element taken substantially along the plane described by the lines 2-2 of Figure 1, illustrating the filter element disposed between opposite element locators in a filter housing and showing a first embodiment of the filter element with inner support wrap;

Figure 3 is a cross-sectional side view taken substantially along the plane described by the lines 3-3 of Figure 2, illustrating the pleat section of the filter element;

Figure 4 is an enlarged cross-sectional view of one of the end cap structures of the filter element of Figure 2;

Figure 5 is an enlarged cross-section the other of the end cap structures of Figure 2; and

Figure 6 is a cross-sectional configuration of a filter element similar to Figure 2, but illustrating a second embodiment of the filter element with inner plural support bands.

Referring to the drawings, and initially to Figures 1-3, a filter element constructed according to the principles of the present invention is indicated generally at 10. The filter element 10 is designed to be located within a filter housing of a filter assembly, and to receive at least one element locator of the filter housing. A pair of element locators are identified at 12 and 14 in Figure 2 disposed co-axial with one another at opposite ends of the filter element. Each element locator has a central fluid passage 15, 16, respectively, for directing fluid into or out of the filter element. A perforated metal support core, indicated generally at 18, is attached to element locator 14 and extends centrally within the filter housing. As will be described herein in more detail, the support core 18 removably receives the filter element 10.

The filter element 10 includes a filter media structure, indicated generally at 20, which preferably has a cylindrical form with opposite ends enclosed by end caps 22, 24. One preferred structure for the filter media is a multi-layered structure illustrated in Figure 3. This multi-layered structure includes an outer support mesh or screen 30 formed from a thermoplastic synthetic resinous material, such as nylon or polyester, which can be woven or extruded. Other conventional thermoplastic synthetic resinous material can also be employed for the outer support mesh, as should be known to those skilled in the art. In any case, the support mesh should have sufficient strength to withstand differential fluid pressure across the filter element.

A microfiber capacity layer 31, also referred to as a prefilter layer, is located inside of the outer support mesh 30. The prefilter layer increases the dirt holding capacity of the filter element, and preferably is formed from borosilicate microglass fibers with acrylic binder. Again, other conventional materials can be used for the capacity layer, as should also be known to those skilled in the art.

Disposed between and immediately adjacent the inner surface of the outer support mesh 30 and the outer surface of the prefilter layer 31, is an adhesive web layer 32. The adhesive web layer preferably comprises a non-woven, polyester-based thermoplastic adhesive. The adhesive is heat sensitive and can be heat activated to i) join the outer support mesh to the capacity layer, and ii)facilitate maintaining the shape and structural integrity of the pleats after the web has thermally set. Preferable adhesive web material for the present invention is commercially available under model/designation Nos. SH 4200 and SH 4275 from Applied Extrusion Technologies, Inc. of Middletown, Delaware.

Immediately adjacent the inner surface of the capacity layer 31 is a microfiber filtration layer 36. The microfiber filtration layer is preferably comprised of the same material as the prefiltration layer, for example borosilicate microglass fibers with acrylic binder, but with a finer fiber or tighter structure than the prefiltration layer. Generally, the microfiber filtration layer defines the filtration efficiency of the filter element, and is generally about ten times the filtration efficiency of the prefiltration layer.

Immediately adjacent the inner surface of the filtration layer 36 is an inner support mesh layer 38. The inner support mesh layer 38 also preferably comprises the same material as in the outer support mesh layer 30, such as a thermoplastic synthetic resinous material which can be woven or extruded.

The thickness and porosity of the layers described above can vary depending upon the particular filtering application, and can be determined using simple experimentation. Further, as should be apparent to those skilled in the art, the preferred filter media structure described above is a combustible or biodegradable structure such that the filter media can be relatively easily disposed of in a commercial landfill. However, while the filter media structure 20 is preferably formed in the multi-layered structure described above, it should be apparent to those of ordinary skill in the art that the filter media structure can have other known single or multi-layered structures.

In any case, the filter media 20 is preferably pleated, that is, the filter media includes axially-extending pleats extending from end cap 22 to end cap 24. Each pleat has a radially outer pleat peak (open end), such as indicated at 50, and a radially inner pleat peak (closed end), such as indicated at 52. Each pleat also includes sidewalls, such as illustrated at 54 and 56, which together with the inner pleat peaks 50 and outer pleat peaks 52 define a series of radially-outward opening pleat cavities around the circumference of the filter element. The cylindrical pleated filter media also defines a cylindrical cavity, indicated generally at 58 in Figure 1, centrally within the filter element. The techniques for pleating or corrugating the filter media are conventional in nature, and can include hand-forming or forming using a pleat machine.

To provide rigidity and structural integrity for the pleated filter media, an inner support wrap, indicated at 64 in Figures 2 and 3, is disposed within the cylindrical cavity of the filter element. Inner support wrap 64 preferably comprises a porous, fibrous filter media of a non-woven thermoplastic synthetic resin, such as polyester. The inner support wrap is preferably a spun-bonded material. A "spun-bonded" material can be prepared by depositing extruded thermoplastic synthetic resin filaments into a non-woven mat while the filaments are in a soft or partially molten form. The soft fibers generally thermally adhere to one another, i.e., melt bond, and when cooled, form an integral mass of non-woven filamentary structure. The inner-support wrap can also be formed from spun-bonded glass fibers, although polyester fibers are preferred. Support wrap 64 preferably has a permeability of at least ten times the permeability of the filter media 10, and does not appreciably affect the pressure drop across the filter element. As should be apparent from the above, the support wrap is also preferably formed from a combustible or incineratable material, similar to the material forming the filter media, such that the composite structure can be relatively easily incinerated or disposed of in a commercial landfill.

The support wrap 64 is formed in a cylindrical or tubular form, with the outer surface of the support wrap being joined to the inner pleat peaks 52 of the pleats. Preferably, the support wrap 64 is joined to the inner pleat peaks by conventional adhesive which can be applied to the

outer surface of the support wrap in one or more beads (circumferentially or helically applied), or alternatively, applied continuously in a coating or layer across the entire outer surface of the support wrap. A layer of adhesive is indicated at 65 in Figure 3. The adhesive bonds the inner pleat peaks to the support wrap, which fixes the inner pleat peaks with respect to one another and provides rigidity and structural integrity for the pleated filter media. The support wrap is of course unattached and is spaced from the filter media at the locations between the pleats. The ends of the support wrap are preferably spaced a short distance from the ends of the filter media such that the adhesive for the end caps can easily bond to the filter media in layers and the end caps can be securely bonded to the ends of the filter media. Otherwise, the support wrap extends along the entire axial length of the filter media.

The filter element is designed to be manufactured using common manufacturing techniques. For example, the inner support wrap can be wound around a mandrel, with the side edges of the support wrap overlapping one another. Although not necessary, the overlapping side edges can be adhesively secured together. A mass of adhesive can then be applied across the outer surface of the support wrap, such as in one or more beads, or in a continuous layer across the entire outer surface of the support wrap. The adhesive is preferably a commercially-available adhesive, such as a two-part urethane or epoxy with a catalyst which is heat or air curable, or can be other conventional adhesives, such as a single component adhesive of heat curable urethane or epoxy. Appropriate adhesives are well known to those skilled in the art. The pleated filter media can then be disposed in surrounding relation to the support wrap in a cylindrical form. The side edges of the filter media can be secured to one another, such as by a band or strip of adhesive applied along the adjacent side edges, as is also well-known in the art. The inner support wrap allows the preassembled filter media to be easily removed from (slid off) the mandrel and retain its cylindrical form.

As illustrated in Figures 4 and 5, end caps 22 and 24 are then located on the opposite end of the filter media. The end caps are preferably formed from conventional end cap material, for

example a thermoplastic such as injection-molded nylon, or other material which is combustible and/or biodegradable, and which can be readily incinerated or disposed of in a landfill. The end caps are adhered to the ends of the filter media using an appropriate adhesive or potting compound.

End caps 22 and 24 preferably both include imperforate annular disks 68, 69, respectively, disposed against the ends of the filter media 20. An outer annular flange extends axially inward around the periphery of each end cap, partially along the outer surface of the filter media. Specifically, outer annular flange 70 on end cap 22 extends inwardly from disk 68, while outer annular flange 71 on end cap 24 extends inwardly from disk 69. Each end cap also includes a central opening for receiving an element locator of the filter housing. Specifically, end cap 22 includes central opening 72 receiving element locator 12, while end cap 24 includes central opening 73 receiving element locator 14. Of course, if only one element locator is present, then one of the end caps can be a continuous uninterrupted disk, with no central opening. In any case, each end cap preferably includes an inner annular flange portion 74, 75, respectively, surrounding the opening in the end cap. The annular flanges also extend axially inward partially along the inner surface of the filter media.

As indicated previously, the support wrap does not extend out entirely to the ends of the filter media, but rather terminates at an axial location spaced from the ends of the filter media and also from the inner annular flange of the end cap. The spacing of the support wrap from the ends of the filter media allows the end caps to be easily located on the ends of the filter media and the adhesive to securely attach the end caps to the layers of the media. The inner annular flanges on the end caps preferably have about the same radial thickness (.030 inches) as the support wrap, such that a substantially flush and continuous inner surface on the filter media is provided.

Each inner flange 74, 75 on the end caps also has a radially-inward facing groove which receives an elastomeric O-ring 80, 82, respectively. Each O-ring seals against the element locator for the housing to provide a fluid-tight seal between the filter element and the filter housing at both ends of the filter element. While the element locators can of course have different configurations

depending upon the particular application, the element locator 12 illustrated in Figure 4 has a cylindrical sleeve or collar 84 with an outer smooth surface which is sealed by O-ring 80 of end cap 22. Element locator 12 also includes an outwardly-projecting shoulder 86 with a flat inner surface 88 which can abut the outer surface 90 of flange 72, however, O-ring 80 allows flange 72 to be located along sleeve 84 at any axial location, and still maintain a proper seal between the filter element and the end cap.

At the opposite end of the filter element illustrated in Figure 5, element locator 14 preferably has substantially the same structure as the element locator 12, that is, a cylindrical sleeve or collar 94 with a smooth exterior surface and an outwardly projecting shoulder 96. However, instead of O-ring seal 82 being sealed directly to collar 94, O-ring seal 82 can be sealed to the outer surface of the cylindrical inner support core 18. Specifically, inner support core 18 has an outer annular flange 100 preferably formed of the same material as the support core (metal) and secured at one end thereto such as by welding. The inner support core 18 can received around the annular flange and located within an annular channel formed at the inner end 102 of the flange. The annular channel provides that the exterior surface of flange 100 is substantially flush with the exterior surface of core 18. Flange 100 in turn is attached in sealed relation to element locator 14. Specifically, flange 100 can have an inner annular groove which receives an elastomeric O-ring 106. O-ring 106 seals against the outer surface of collar 94 on element locator 14. Flange 100 can be secured to element locator 14 such as by the compressive force of O-ring 106, or by other means which allows the support core to be removed from the element locator. Of course, inner support core 18 can also be formed in one piece or otherwise permanently secured to element locator 14 if the application so dictates, however, the removable end flange 100 on the support core allows the coreless filter element to be retrofitted to existing filter housing designs, and also to be easily removed and inspected, if necessary.

As indicated above, the support tube is preferably comprised of metal and is formed in a cylinder by bringing opposite side edges of a sheet of perforated metal together and securing the

edges together by, e.g., welding. A second annular flange 108 is preferably formed of the same material as the support core (metal) and secured to the other end of the core such as by e.g., welding. The support core 18 can also be received in an inner annular groove on the second annular flange such that the outer surface of the support core is substantially flush with the second annular flange. First annular flange 100 and second annular flange 108 provide smooth distal ends for the support core so as not to catch or tear the support wrap. However, smooth ends could also be provided using other techniques such as coining or crimping the ends of the support core over to form rolled edges.

To assemble filter element 20 in the filter housing, the inner support core 18 is initially secured to element locator 14. Next, filter element 20 is disposed over the support core 18, with end cap 24 being first received over the support core, and inserted over the support core until O-ring 82 seals against flange 100. Filter element 20 slides smoothly and cleanly over the inner support core by virtue of the smooth interior surface of support wrap 64, with the support wrap acting as a spacer to allow end cap 24 to slide easily past the support core. Preferably, when assembled, support wrap 64 is in adjacent, closely surrounding relation with inner support core 18 such that the inner support core provides longitudinal and radial support for filter media 20. In addition, support wrap 64 prevents the pleated media from directly contacting the inner support core, and catching or binding along the support core as the filter element is inserted. Finally, the opposite element locator 12 is attached to the filter element, with the O-ring seal 80 on end cap 22 sealing against element locator 12. Although not shown, element locator 12 can be incorporated into a removable end cap of the filter housing.

In removing a spent or used filter element from the housing, the above process is reversed, that is, element locator 12 is detached from the filter element, and the filter element is slid off the inner support core 18. Again, the filter element can be removed in a smooth and easy manner because of the support wrap 64 sliding easily against the inner support core 18.

According to another embodiment of the present invention, as illustrated in Figure 6, the filter element 10 can alternatively include one or more support bands extending circumferentially around the inner surface of the filter media in the cylindrical cavity 58. For example, Figure 6 illustrates three separate annular support bands 120, 122 and 124 disposed in spaced-apart relation around the inner surface of the filter media. Support band 120 can be located close to one end of the filter media (proximate end cap 22), support band 124 can be located close to another end of the filter media (proximate end cap 24) and support band 20 can be located between support band 120 and support band 124 at approximately the center point along the filter media. Preferably the outer two support bands 120 and 124 are spaced apart from the end caps of the filter media such that fluid flow through the filter media is allowed between the outer support bands and the end caps. This also allows the end caps to be securely adhesively fixed to the ends of the filter media, as previously described.

The support bands are preferably formed from an imperforate thermoplastic material such as nylon, or can be comprised of a fibrous filter material such as described previously with respect to the support wrap. Again, it is preferred that the material is combustible or biodegradable so as to be easily disposed of in a landfill. Also, the support bands preferably have the same thickness as the support wrap described previously (.030 inches), and are joined to the inner peak pleats of the filter media such as by depositing a bead or layer of adhesive along the outer surface of the bands.

As with the support wrap, the support bands provide structural integrity for the pleats on the filter element, and more specifically, prevent the pleats from moving relative to one another such that the filter element retains its cylindrical form. The support bands also allow the filter element to be easily located over the inner support core 18 as the bands have a smooth inner surface which is easily slid over the core, and prevent the pleats from directly contacting the core. The bands also act as spacers to allow the end cap 24 to slide pass the support core when inserting the filter element over the core. The number, spacing and width of the support bands can be

chosen depending upon the particular application, and can be determined by simple experimentation.

The filter element can be assembled in much the same manner as described previously, with the support bands being disposed around the mandrel and a layer of adhesive applied to the outer surface of the support bands, with the pleated or corrugated filter media then disposed in a cylinder form around the bands. While the support bands are disclosed as extending annularly around the inside surface of the filter media, it is also within the scope of present invention to provide one or more support bands in a spiral or helical fashion circumferentially around the inside surface of the filter media, as along as the support band(s) provide sufficient strength and integrity for the filter element.

In either of the embodiments described above, the present invention provides a novel and unique coreless filter element which can be easily located over a support core integral with a filter housing, and removed from the support core and replaced when necessary. According to either of the embodiments described above, the support wrap or band(s) provide integrity and strength for the pleated filter media without requiring an outer wrap surrounding the filter element, and can be easily manufactured using common techniques. Finally, the filter element of the present invention is particularly designed with incineratable or biodegradable components which can be disposed of in a commercial landfill.

## CLAIMS

**WHAT IS CLAIMED IS:**

1. A coreless filter element (10) having cylindrical filter media (20) with longitudinally-extending pleats extending from one end of the filter media to another end of the filter media, said pleats having closed ends (52), open ends (50), and opposing sidewalls (54, 56) extending between respective closed ends and open ends which define outwardly-opening pleat cavities around the filter element, a radially-inner surface of the closed ends of the pleats defining a central, longitudinally-extending cylindrical cavity (58) within the filter media, characterized in that an inner cylindrical support wrap (64) formed from a layer of porous, fibrous filter media is disposed within the central cavity of the cylindrical filter media and has a radially outer surface joined to the radially-inner surface of the closed ends (52) of the pleats.

2. The filter element (10) as in claim 1, further characterized in that a mass of adhesive (65) is disposed between and against the outer surface of the support wrap (64) and the closed ends (52) of the pleats.

3 The filter element (10) as in claim 1, characterized in that said support wrap (64) comprises a wrap of flexible material having circumferential ends which are in overlapping adjacent relation to one another.

4. The filter element (10) as in claim 1, characterized in that said support wrap (64) has a permeability of at least 10 times the permeability of the filter media (20).

5. The filter element (10) as in claim 4, characterized in that said support wrap (64) is formed from spun-bonded polyester material.

6. The filter element (10) as in claim 1, further characterized as including an imperforate end cap (22, 24) bonded to each end of said filter media (20), each end cap including an annular disk (68, 69) with a central opening (72, 73), a radially-inward facing groove around the central opening to each end cap, and a resilient O-ring seal (80, 82) disposed within each groove, and projecting radially-inward into the opening.

7. The filter element (10) as in claim 1, wherein said filter media (20) is characterized as including a multi-layered structure having i) an outer layer (30) of a support mesh, ii) an adhesive web layer (32) disposed adjacent a radially inner surface of the support mesh, iii) a microfiber capacity layer (31) disposed adjacent a radially inner surface of the adhesive web layer, iv) a microfiber filtration layer (36) disposed adjacent a radially inner surface of the capacity layer, and v) an inner layer (38) of a support mesh disposed adjacent a radially inner surface of the filtration layer.

8 The filter element (10) as in claim 1, characterized in that the open ends (50) of said pleats are self-supporting and are without an outer wrap interconnecting the pleats.

9. A filter assembly having a first fluid conduit (12) and a second fluid conduit (14) to direct fluid into or out of the assembly,

a cylindrical perforated metal support core (18) connected to the second fluid conduit (14) and extending toward the first fluid conduit (12),

a cylindrical filter element (10) removably received over said support core (18), said filter element including filter media (20) having longitudinally-extending pleats extending from one end of the filter element to another end of the filter element, an imperforate end cap (22, 24) adhesively bonded to each end of the filter element, each of said end caps including an annular disk (68, 69) having a central opening (72, 73), one of said end caps (23) receiving said support core (18) and including a radially-inward facing groove around the central opening and a resilient O-ring seal (82)

disposed in the groove in sealing relation with the suuport core (18), and the other of said end caps (22) receiving said first fluid conduit (12) and including a radially-inward facing groove around the central opening and a resilient O-ring seal (80) disposed in the groove in sealing relation with the first fluid conduit (12), said pleats of said filter media having closed ends (52), open ends (50) , and opposing sidewalls (54, 56) extending between respective closed ends (52) and open ends (50) which define outwardly-opening pleat cavities around the filter element, a radially-inner surface of the closed ends of the pleats defining a central, longitudinally-extending cylindrical cavity (58) within the filter media, characterized in that:

an inner cylindrical support wrap (64) formed from a layer of porous, fibrous filter media is disposed within the central cavity (58) between said closed ends (52) of the pleats and the support core (18) , and has a radially outer surface joined by adhesive (65) to the radially-inner surface of the closed ends (52) of the pleats.

10. The filter assembly as in claim 9, wherein said filter media (20) is characterized as including a multi-layered structure having i) an outer layer (30) of a support mesh, ii) an adhesive web layer (32) disposed adjacent a radially inner surface of the support mesh, iii) a microfiber capacity layer (31) disposed adjacent a radially inner surface of the adhesive web layer, iv) a microfiber filtration layer (36) disposed adjacent a radially inner surface of the capacity layer, and v) an inner layer (38) of a support mesh disposed adjacent a radially inner surface of the filtration layer.

11. The filter assembly as in claim 9, wherein the open ends (50) of said pleats are self-supporting and are without an outer wrap interconnecting the pleats.

12. The filter assembly as in claim 9, wherein said support wrap (64) has a radially inner surface adjacent said support core, and an opposite, radially outer surface adjacent said radially inner surface of the closed ends of the pleats.

13. A coreless filter element (10) having cylindrical filter media (20) with longitudinally-extending pleats extending from one end of the filter media to another end of the filter media, said pleats having closed ends (52), open ends (50), and opposing sidewalls (54, 56) extending between respective closed ends and open ends which define outwardly-opening pleat cavities around the filter element, a radially-inner surface of the closed ends (52) of the pleats defining a central, longitudinally-extending cylindrical cavity (58) within the filter media, characterized in that inner cylindrical support means (64, 120, 122, 124) is disposed within the cylindrical cavity (58) of the filter media with a radially outer surface joined by adhesive (65) to the radially-inner surface of the closed ends (52) of the pleats for providing structural integrity for the pleats and preventing the closed ends of the pleats from moving with respect to one another.

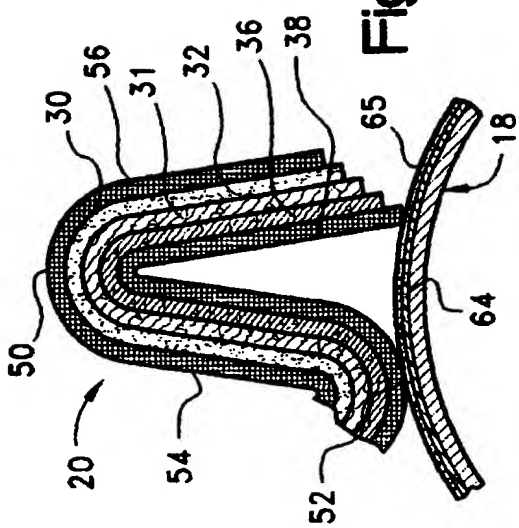



Fig. 3

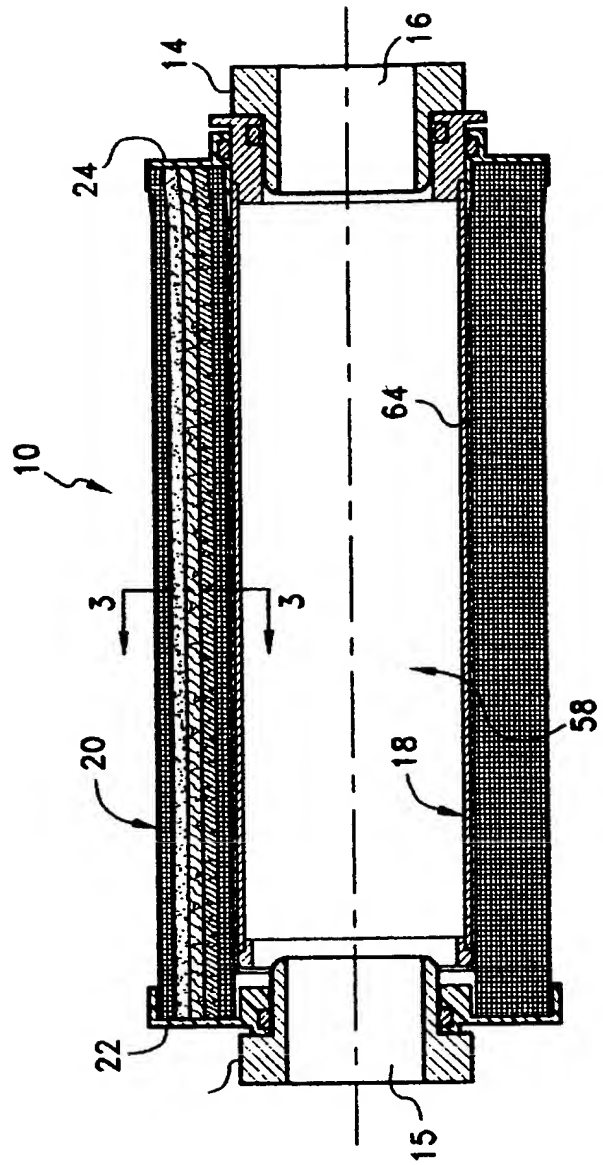



Fig. 2

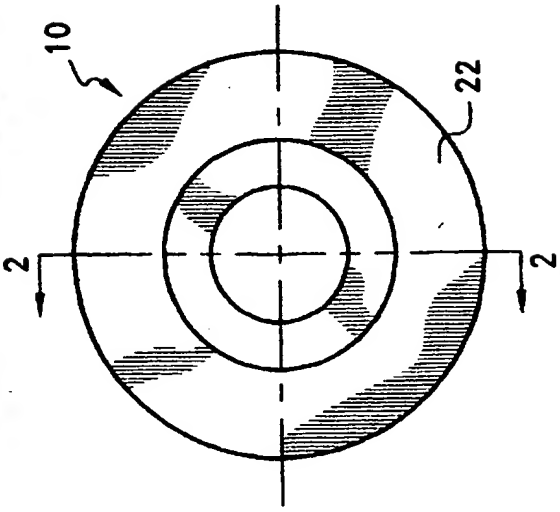
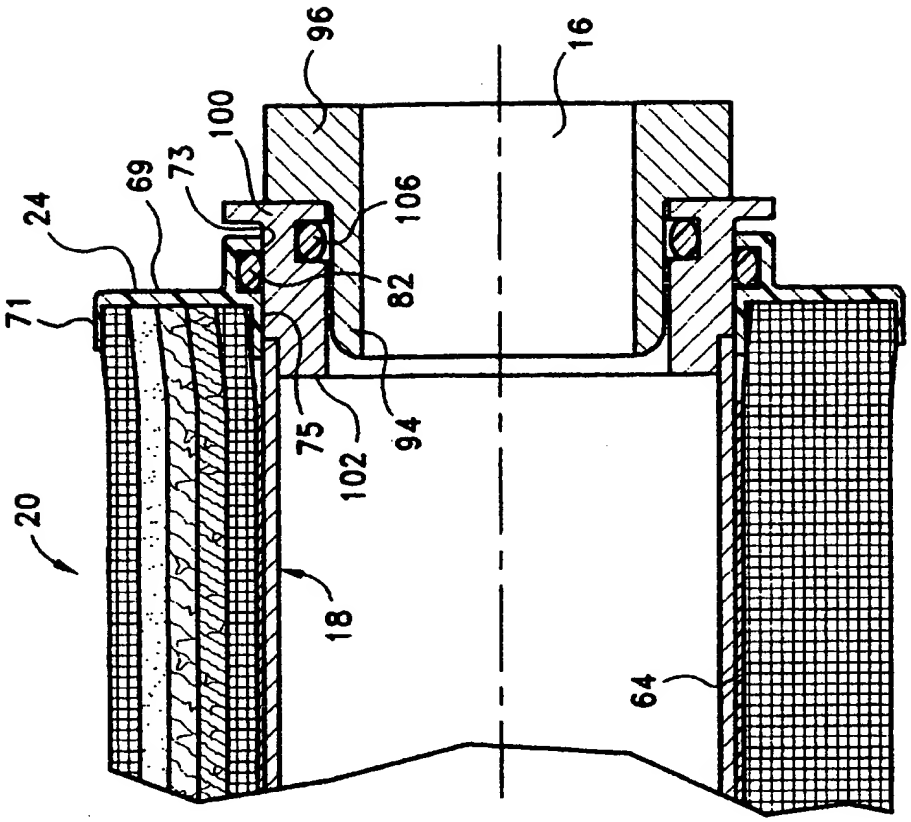



Fig. 1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64

Fig. 5

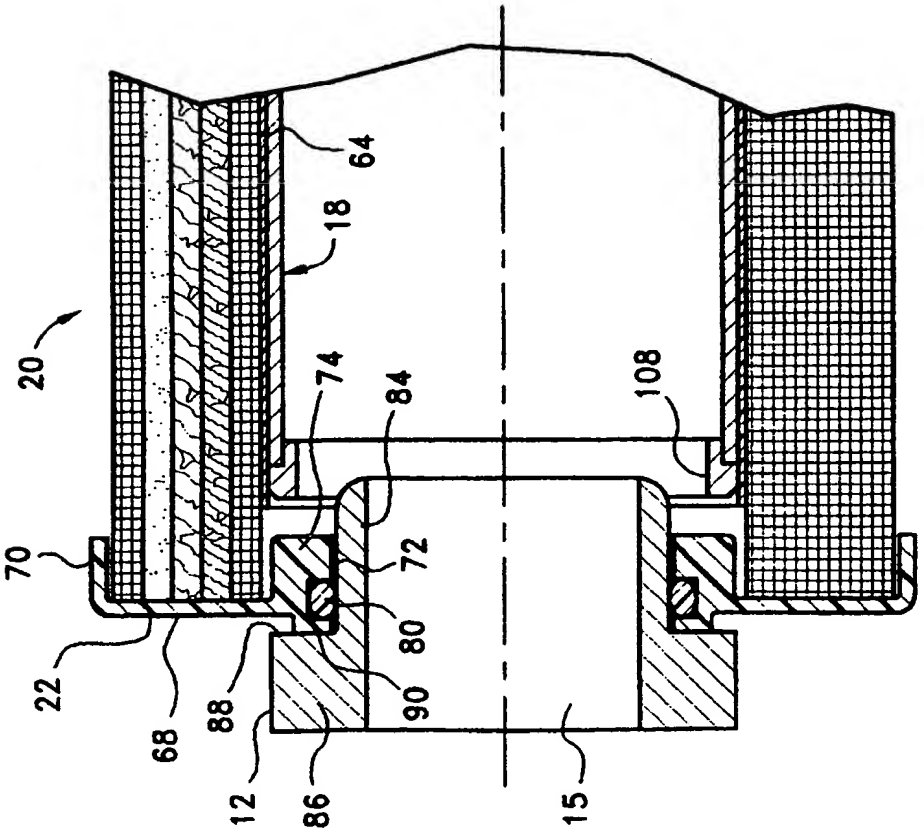
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Fig. 4

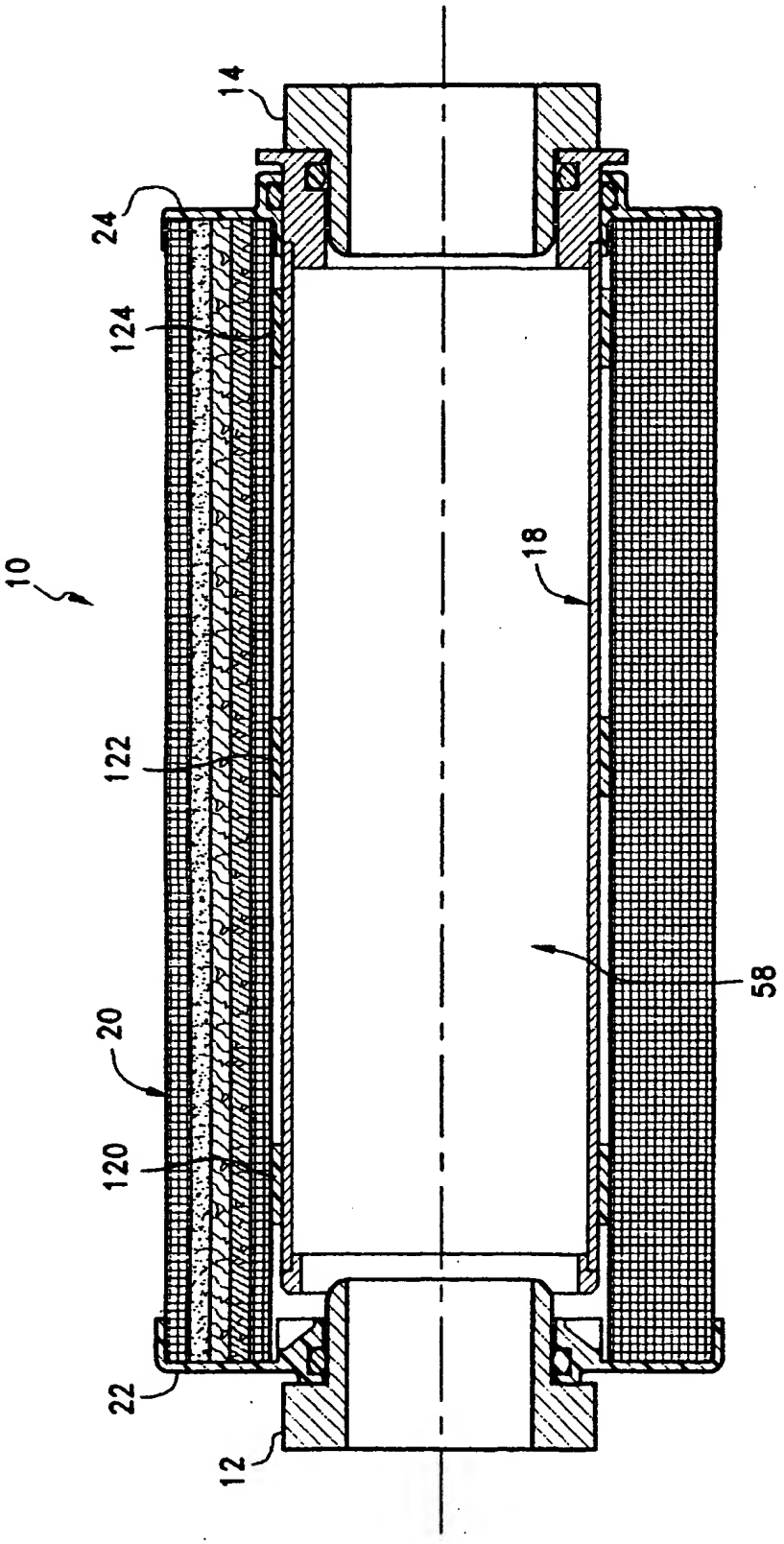


Fig. 6

# INTERNATIONAL SEARCH REPORT

In. ional Application No
PCT/US 97/02308

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B01D27/06 B01D46/52 B01D63/14 B01D29/11

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 B01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category * | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

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"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 22 May 1997 | 12.06.97 |

| Name and mailing address of the ISA | Authorized officer |
|---|---|
| European Patent Office, P.B. 5818 Patentlaan 2<br>NL - 2280 HV Rijswijk<br>Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,<br>Fax (+31-70) 340-3016 | Persichini, C |

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In. ional Application No
PCT/US 97/02308

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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